ISOGA: Integrated Services Optical Grid Architecture for Emerging Scientific Collaborative Applications

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Motivation

- ## Current Deployment
  - Support multi-Gigabit rate & latency-sensitive scientific applications
  - Interconnect shared computing Grid clusters
    - TeraGrid, OptIPuter
  - Optical GigaPoP / Peering Exchange
    - StarLight (Chicago), NetherLight (Amsterdam)
  - Homogeneous single-domain optical-switched LAN, MAN, WAN
    - All-optical Switched: UIC all-optical LAN, OMNInet MAN
    - OEO Switched: DOE Ultra-Science Net, Canarie CAnet*4
- ## Emerging Requirements from Collaborative Scientific Application Users
  - User-centric dynamic lightpath provisioning
  - Multiple QoS support for multimedia transport services
  - Deploy applications over heterogeneous multi-domain optical-switched networks
    - Interconnect optical subnets to backbone network and peering exchanges
    - Mixed all-optical and OEO switching

# Interconnected Optical-Switched Networks
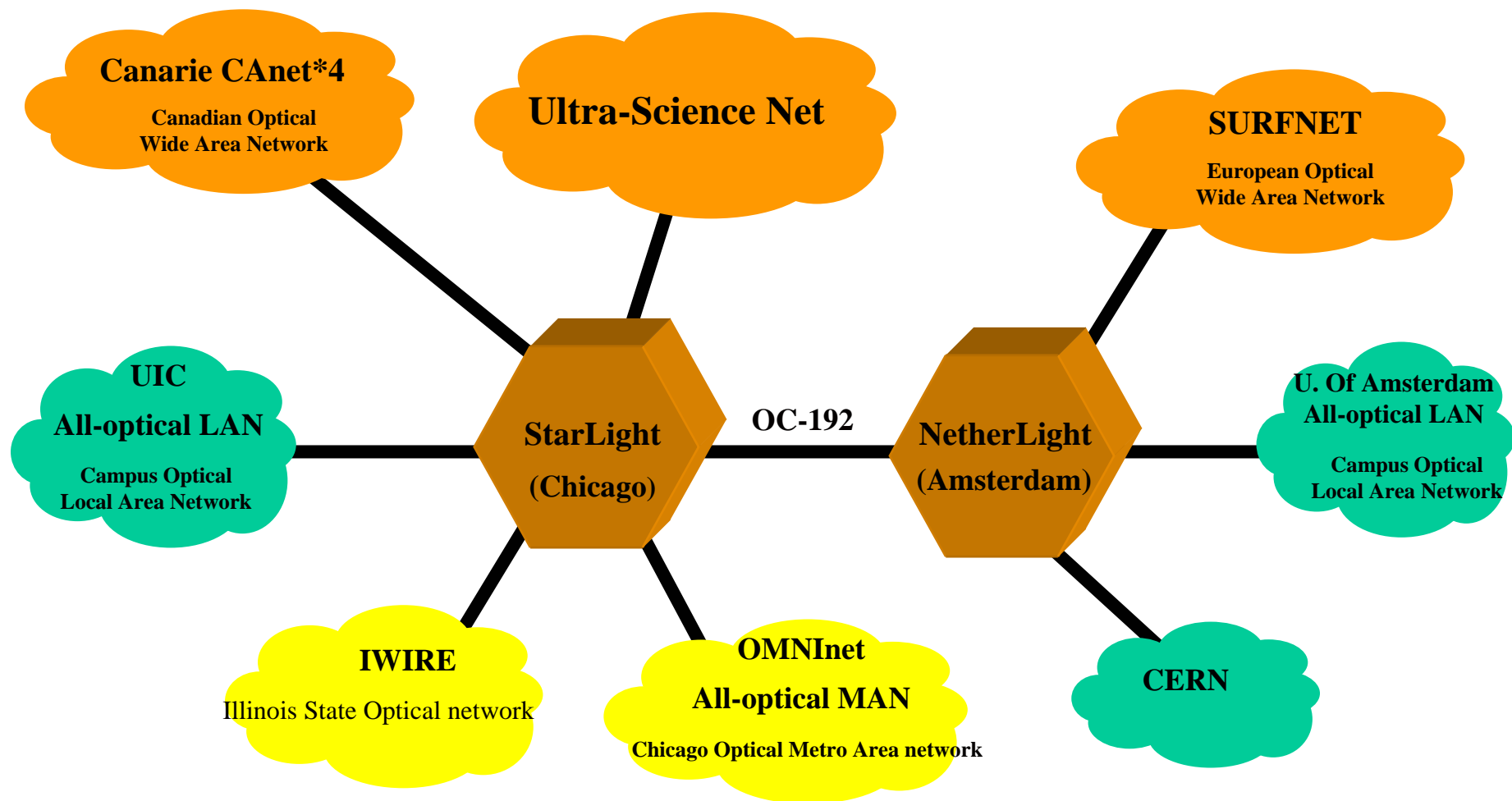
Project Objectives

- Intelligent Control Plane Services over Optical-Switched Network
  - Enable user-centric or application-centric dynamic lightpath provisioning
    - On-demand setup and advanced scheduling of lightpaths
    - Dynamic lightpath restoration or self-healing
  - Enable multi-domain lightpath provisioning
    - Interoperate heterogeneous networks.
- Advanced Transport Services over Optical-Switched Network
  - Enable multiple transport services
    - Gigabit-rate stream traffic (single lambda per application).
    - Sub-gigabit-rate stream traffic (sub-lambda per application).
    - Terabit-rate stream traffic (multiple lambdas per application).
    - Variable Burst traffic
    - Multicast stream traffic
  - Enable optical network-aware middleware and transport Protocols

Integrated Services Optical Grid Architecture (ISOGA)

- Intelligent Control Plane Services
  - Dynamic User-centric Signaling Optical Negotiator (DUSON)
    - Extend IETF GMPLS control plane.
    - Enable users or applications with optical network awareness to control dynamic lightpath provisioning.
  - Photonic Interdomain Negotiator (PIN)
    - Interoperate optical-switched networks with incompatible control planes.
    - Enable multi-domain dynamic lightpath provisioning.
- Advanced Transport Services
  - Integrated Services Optical Network (ISON)
    - Extends an optical-switched network with multiple transport services to satisfy the diverse bandwidth and communication requirements of emerging scientific applications.
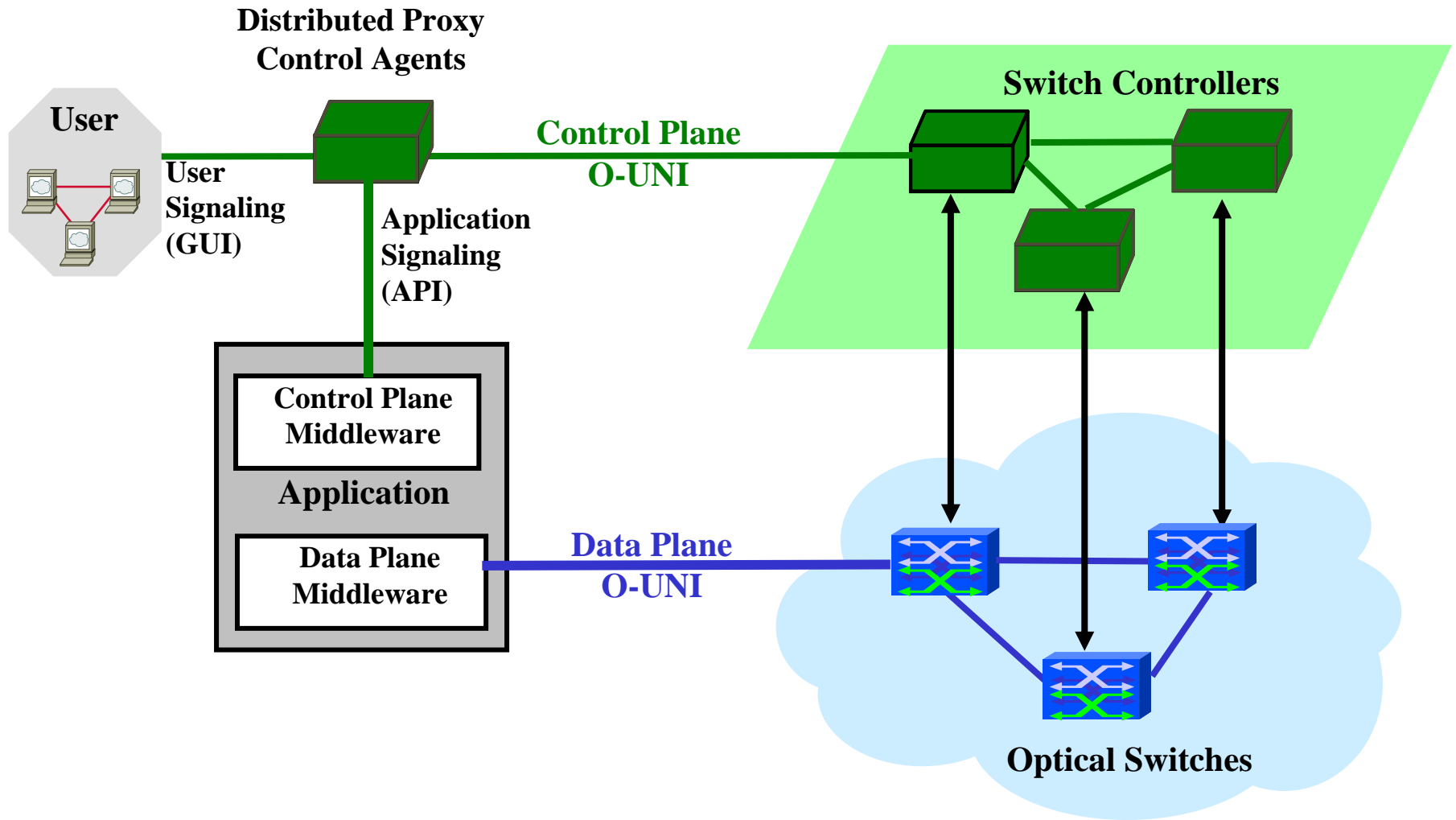
ISOGA Components
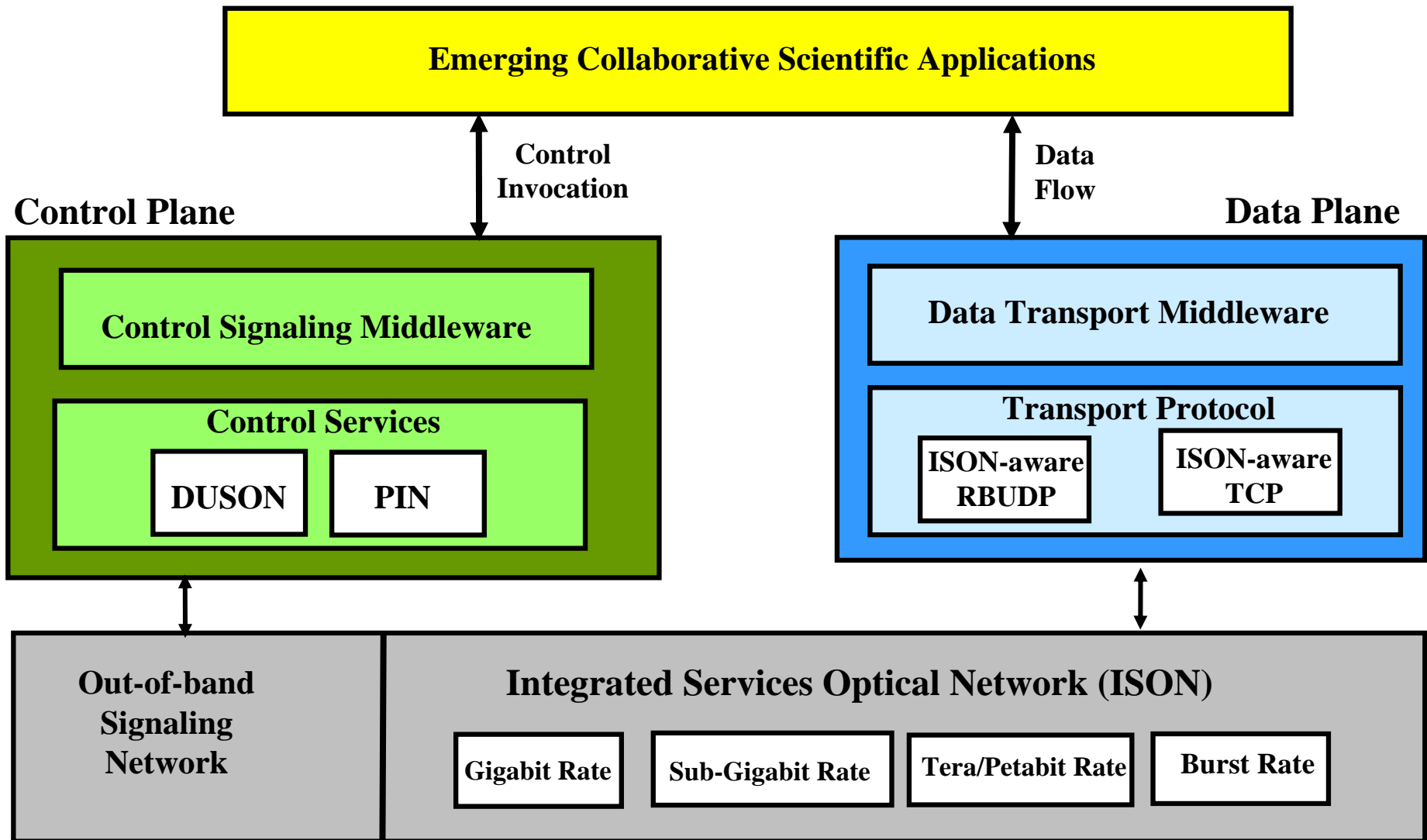
Dynamic User-centric Signaling Optical Negotiator (DUSON)

- **Intelligent User & Application Signaling**
  - Enable user (via control GUI) and application (via control API) to manipulate dynamic lightpath provisioning.
  - Support distributed proxy control agents for users/applications to engage in control plane services.

- **Dynamic Efficient Fast Establishment & Restoration**
  - Propose Robust Fast Optical Reservation Protocol (RFORP)
    - Minimize reservation failure and delay via localized rerouting and parallel reservation processing.
  - Enable virtual Protected Lightpaths
    - Optimize restoration resource allocation and delay

- **Lightpath Advance Scheduler**
  - Extend GARA-based DiffServ scheduler.

DUSON User and Application Signaling

Distributed Proxy Control Agents

User

User Signaling (GUI)

Application Signaling (API)

Control Plane O-UNI

Switch Controllers

Control Plane Middleware

Application

Data Plane Middleware

Data Plane O-UNI

Optical Switches

Photonic Interdomain Negotiator (PIN)

- Interdomain Signaling and Routing Control
  - Domain-level Topology Discovery and Route Selection
  - Multi-domain Optical Resource Reservation

- Multi-domain Provisioning Gateway
  - Enable secure on-demand lightpath provisioning over multiple optical domains with heterogeneous switches and control services.
  - Interoperate optical-switched networks with service translation and mapping.

- User Authentication and Service Authorization
  - Enable domain-level policy-based control.
  - Employ IETF AAA (Authentication/Authorization/Accounting) servers & clients.

- Designed for compliancy with Open Grid Service Architecture (OGSA)
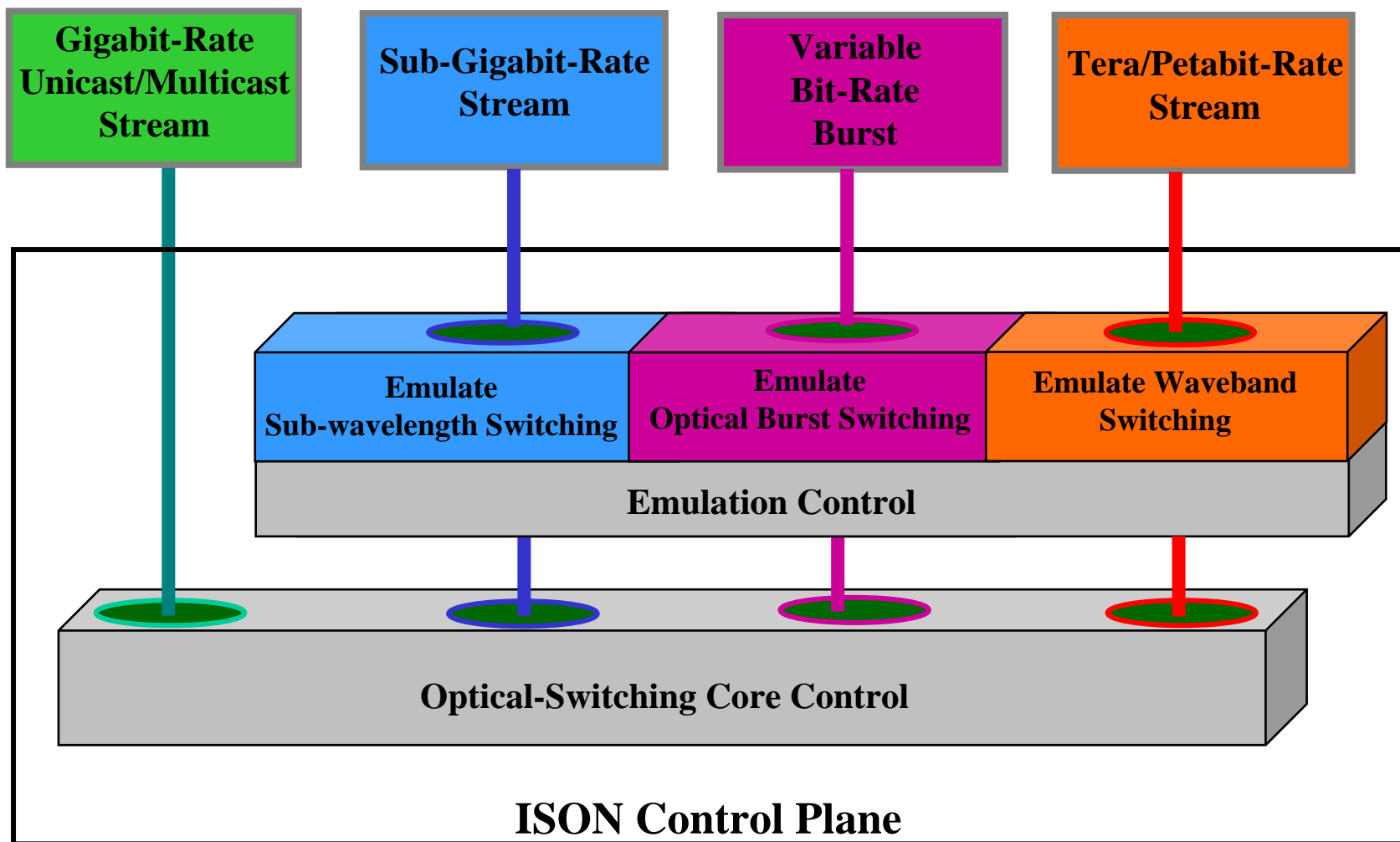 - Enable transparent interoperability and integration among standardized components.
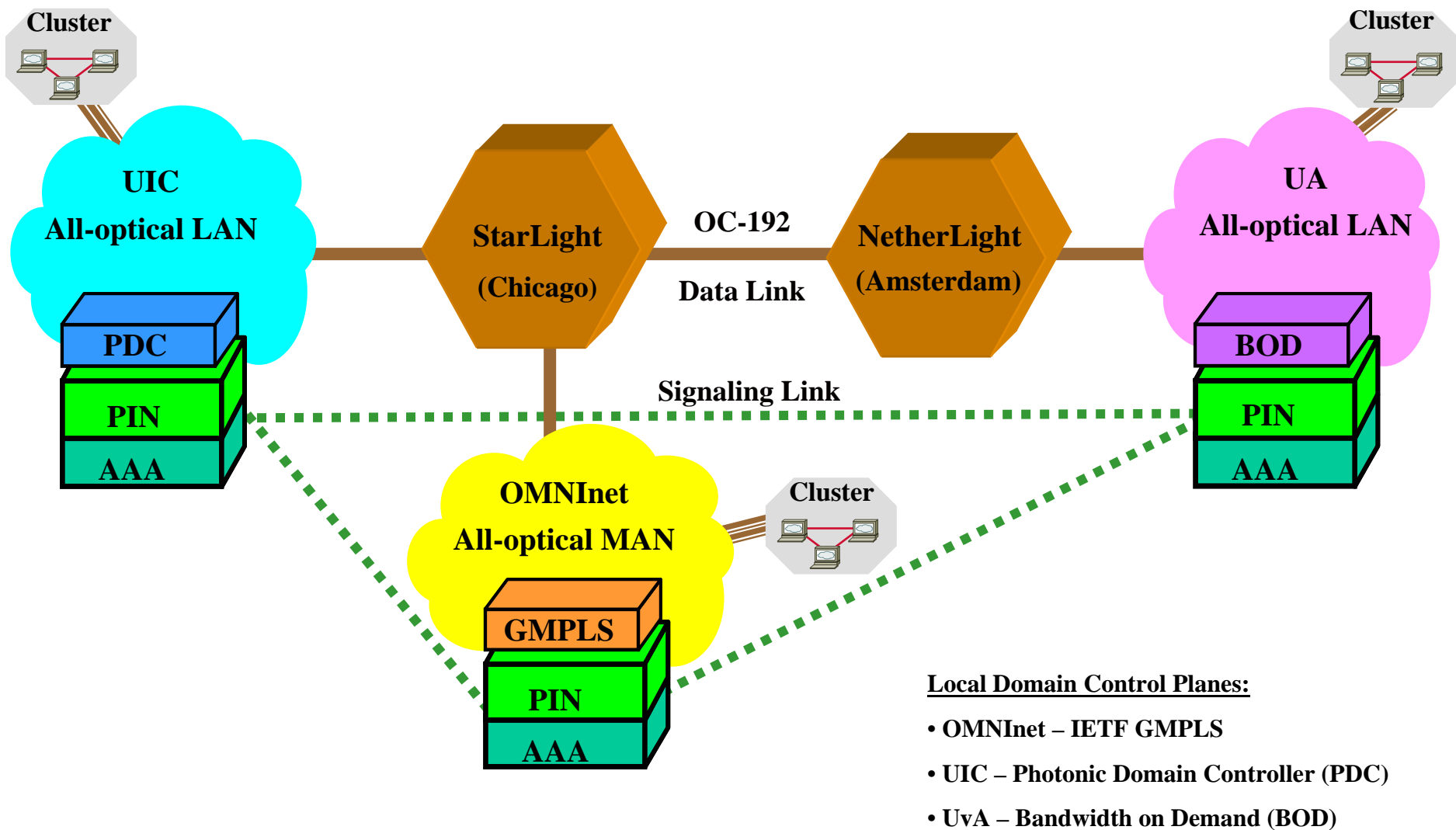
PIN Architecture
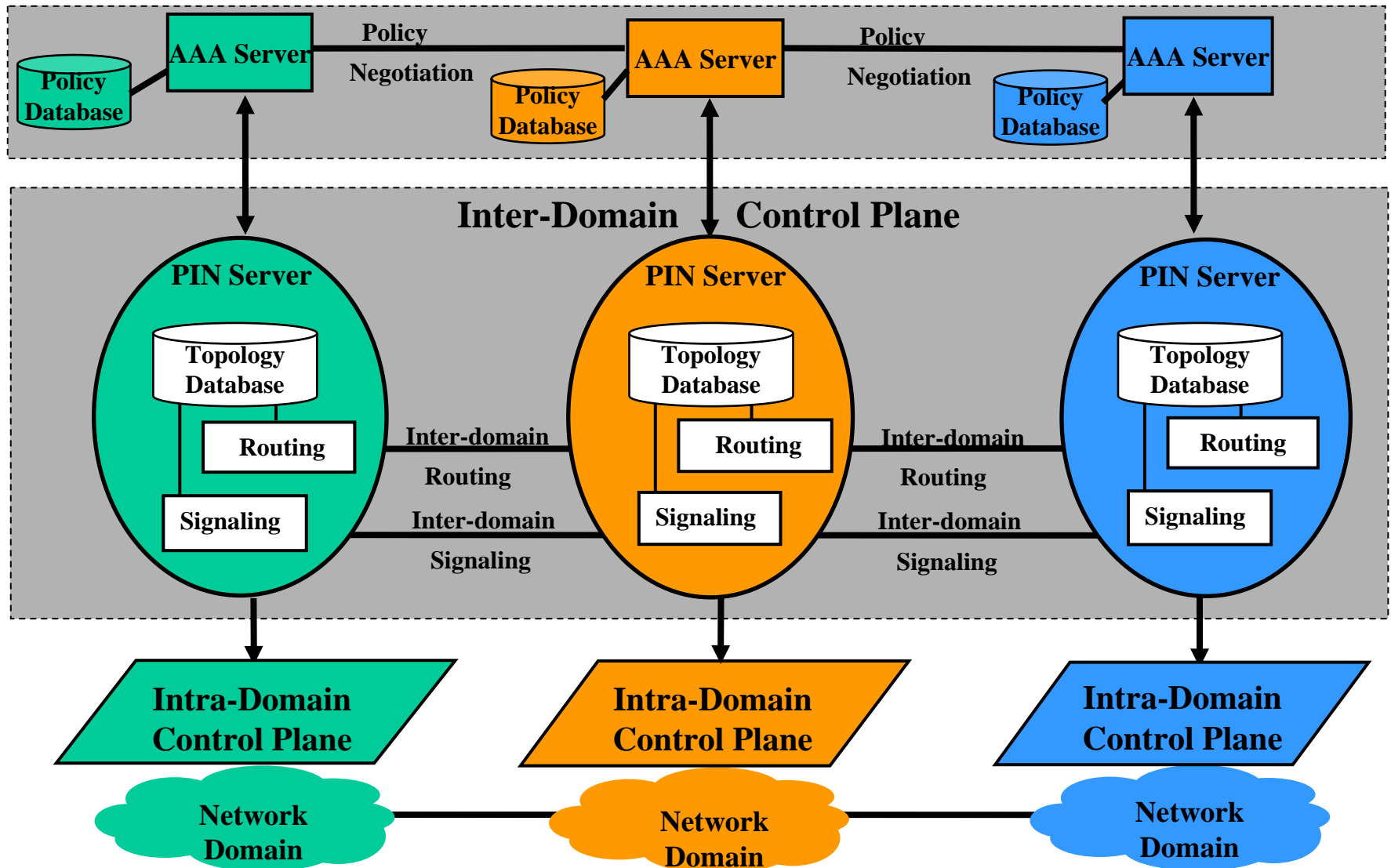
Integrated Services Optical Network (ISON)

- Optical Circuit Switching Service (single lambda per application)
  - Support constant gigabit-rate stream traffic.
  - Default optical network service.
- Emulate Sub-wavelength Switching Service (sub-lambda per application)
  - Support constant sub-gigabit-rate stream traffic.
  - Multiplexing of a single lambda with MPLS labeled logical circuits at edge.
- Emulate Waveband Switching Service (multi-lambda per application)
  - Support constant terabit/petabit rate stream traffic.
  - Inverse multiplexing of lightpaths at edge.
- Emulate Optical Burst Switching Service
  - Support variable bit rate burst traffic.
  - Burst aggregation at edge.
- Optical Multicast Switching Service
  - Support multicast stream traffic.
  - Enable multicast light-tree provisioning over all-optical multicast switch.

# Integrated Services Optical Network (ISON)

Preliminary ISOGA Testbed

Local Domain Control Planes:

• OMNInet – IETF GMPLS

• UIC – Photonic Domain Controller (PDC)

• UvA – Bandwidth on Demand (BOD)

EVL Collaborative Applications over Optical Lambda Grid

- **GeoWall**
  - A geo-science tele-immersive graphics system for large remote sensing, volume rendering imagery, mapping and seismic interpretation.

- **LambdaVision**
  - It envisions situation-rooms and research labs in which all the walls are made from seamless ultra-high-resolution displays fed by data streamed over ultra-high-speed networks from remote visualization and storage servers, and high definition video.

- **LambdaRam**
  - Giant pool of clustered memory to provide lower latency access to large data sets than by swapping to disk.
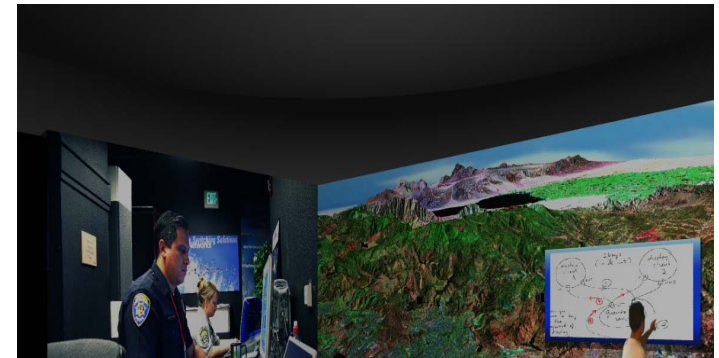
# Project Activities

- **Publication**
  - O. Yu, T. DeFanti, "Collaborative Lambda-Grid over All-Optical Metro Network with Intelligent Application Signaling," accepted for publication in *Proc. SC 2004*, November 2004.
  - O. Yu, "Intercarrier Interdomain Control Plane for Global Optical Networks," in *Proc. IEEE ICC,* June 2004.

- **Workshop Presentation**
  - Presented "Lambda Grid Control Plane" at the Grid ON*Vector Workshop, San Diego, March 2004.
  - Presented "Photonic Interdomain Negotiator" at the MCNC Workshop on Optical Control Planes for the Grid Community, Chicago, April 2004.

- **Demonstration**
  - Through collaboration with University of Amsterdam, on-demand lightpath provisioning was demonstrated over lambda Grid between Chicago & Amsterdam.
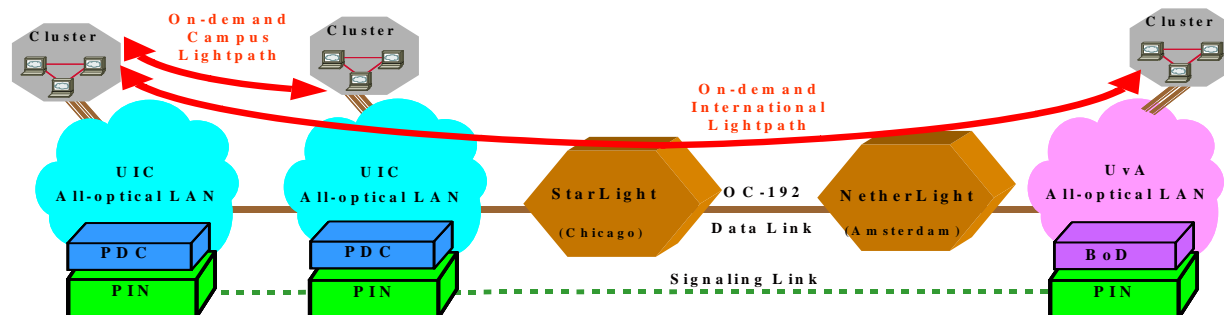
  - Plan to demonstrate AAA-based multi-domain dynamic lightpath provisioning in SC 2004.